OLLSCOIL NA GAILLIMHE
UNIVERSITY OF GALWAY

Autumn Examinations 2022 / 2023

Course Instance Code(s)	4BCT, 3BP, 4BP, 4BS, 1OA
Exam(s)	BSc in Computer Science & Information Technology
	BE in Electronic & Computer Engineering
	BSc General
Module Code(s)	CT414
Module(s)	Distributed Systems
Paper No.	1
External Examiner(s)	Dr. R. Trestian
Internal Examiner(s)	Prof. M. Madden
	*Dr. D. Chambers

Instructions:	Answer any 4 questions.
	All questions carry equal marks.

Duration	2 hours
No. of Pages	4
Department(s)	School of Computer Science
Course Co-ordinator(s)	Dr Colm O'Riordan

Requirements:

Release in Exam Venue	Yes	X	No	
MCQ Answersheet	Yes		No	X

Handout	None
Statistical / Log Tables	None
Cambridge Tables	None
Graph Paper	None
Log Graph Paper	None
Other Materials	None

Graphic material in colour	Yes		No	X

1. Using Java Remote Method Invocation (RMI), write the Java code for a remote compute server application that could be used to remotely execute arbitrary Task objects. The server allows clients to submit Task objects, i.e. objects that implement the Task interface, for remote execution on the server, and clients are then returned the result as a Java object. The design of the system should make it possible for new Task classes to be easily added to the system in the future, making the system very flexible. The design should use Java RMI and Object Serialisation to submit Task objects and to return the result back to the client.

    The following Java interfaces / classes should be provided:

    a: *Compute* - this remote interface should provide a method to upload Task objects to the server and to then run the task and return the result back to the client when execution is complete.   4 MARKS

    b: *Task* - this interface should define an arbitrary Task object that may be passed as a parameter to the compute server.   4 MARKS

    c: *MathTask* – this class provides an implementation of the Task interface and is used to perform some calculation that returns an Integer object. The calculation itself can be just some simple arithmetic e.g., add two numbers.
                                                                                                                                                 6 MARKS

    d: *ComputeServer* - this class should provide an implementation of the Compute interface as well as the code required to initialise the server and make the remote object locatable for clients in the RMI registry. The server runtime should be protected so that objects uploaded to the server can not cause any harm.   6 MARKS

    e: *ComputeClient* – this should provide a simple client program that creates a MathTask object and submits it to the server for remote execution and then displays the result. The client runtime should be protected so that objects downloaded from the server can not cause any harm.   5 MARKS

2.a: What is *message oriented middleware* and what types of messaging models are available in the Java Messaging Service?   5 MARKS

  b: You have been asked to design an application that allows weather updates on specific areas to be retrieved from a central web server and then forwarded periodically to interested client applications. Describe a suitable architecture and design for a distributed application that uses the Java Messaging Service (JMS) to handle the distribution of the weather update messages. Full Java source code is not required but your answer should provide a full description of how the JMS could be used within the application. Also describe how the application might use the Java Naming and Directory Interface (JNDI) as part of this solution.   10 MARKS

  c: Assume that you have been contracted by a large multinational company to develop an enterprise class client / server application that may be accessed by a large number of clients concurrently. You will therefore need to employ some form of load balancing in the design of the application. What type of load balancing systems would you recommend? In this context, describe both low-level and high-level load balancing mechanisms. Also provide some examples of real world systems or services that use the high-level load balancing mechanisms you have recommended.   10 MARKS

3 a: Explain the role of the Proxmox Virtualisation Environment. In this context, what is the difference between a Virtual Machine and a Container and which of these is faster to migrate to a different host on a Proxmox cluster?   6 MARKS

  b: How is it possible to run Virtual Machines at near native speed using Kernel-based Virtual Machine (KVM) infrastructure?   4 MARKS

  c: What is the purpose of the Ceph storage platform and what advantages does it have over traditional RAID based storage? Describe the high level architecture and the main components of the Ceph storage platform. Include in this description details about the following items: Ceph Network, Object Storage Devices and Ceph Pools.   8 MARKS

  d: What are the advantages of grouping physical servers into a cluster? How does a Proxmox cluster implement High Availability and what might cause a Virtual Machine migration to fail?   7 MARKS

4.a: Describe briefly the advantages of using the EJB component framework in the context of high volume distributed object applications. What types of beans may be defined using the EJB framework?   5 MARKS

 b: Suppose you work for a social media company that collects a lot of very large data sets e.g. web logs or other application related data that needs to be stored and analysed. Also assume that the company has access to large scale computing resources based in multiple data centres. Explain how using the Apache Hadoop Distributed File System and its related facilities might help in solving the storage and analysis requirements of the company. Discuss the advantages of this approach over using traditional database systems for this type of data.
                                                         8 MARKS

 c: Describe in detail the MapReduce programming model. Outline the architecture for a MapReduce application that could be used to index a large number of text files by the individual words present in each file. Full source code for the application is not required but your answer should include the data structures that would be used and also clearly explain the purpose and functionality of the map() and reduce() functions in solving this problem.   12 MARKS

5.a: What kind of applications can use Node.js? What is unique about Node.js when compared to other server technologies like e.g. the Apache web server?
                                                         4 MARKS

 b: Explain briefly the purpose of the **npm** utility. Describe exactly the purpose and the effect of running the following command:

   npm install ejs -g   5 MARKS

 c: In the context of implementing a web server type application in Node.js what are the advantages of using the **Express** framework? Write the Node.js code to implement a simple web server, using the Express framework, that responds with a simple text message when the URI /**main** is invoked.   7 MARKS

 d: You have been asked to develop a web-based Todo list application using Node.js and related technologies and the architecture should follow a Model-View-Controller type approach. Based on these requirements, describe a suitable top-level application architecture. Identify the technologies and additional Node.js modules that will be used and explain the role each of these technologies plays in the overall system architecture.   9 MARKS